

Chapter 1 Introduction

1-1. Purpose and Scope

This manual provides (a) guidance on the design and construction of conduits, culverts, and pipes, and (b) design procedures for trench/embankment earth loadings, highway loadings, railroad loadings, surface concentrated loadings, and internal/external fluid pressures.

1-2. Applicability

This manual applies to HQUSACE elements and USACE commands, districts, laboratories, and field operating activities having civil works responsibilities.

1-3. References

The references listed in Appendix A contain accepted methods to design conduits, culverts, and pipes which may be used when specific guidance is not provided in this manual. Related publications are also listed in Appendix A.

1-4. Life Cycle Design

a. General. During the design process, selection of materials or products for conduits, culverts, or pipes should be based on engineering requirements and life cycle performance. This balances the need to minimize first costs with the need for reliable long-term performance and reasonable future maintenance costs.

b. Project service life. Economic analysis used as a part of project authorization studies usually calculates costs and benefits projected for a 50- or 75-year project life. However, many USACE projects represent a major infrastructure for the Nation, and will likely remain in service indefinitely. For major infrastructure projects, designers should use a minimum project service life of 100 years when considering life cycle design.

c. Product service life. Products made from different materials or with different protective coatings may exhibit markedly different useful lives. The service life of many products will be less than the project service life, and this must be considered in the life cycle design process. A literature search (Civil Engineering Research Foundation 1992) reported the following information on

product service lives for pipe materials. In general, concrete pipe can be expected to provide a product service life approximately two times that of steel or aluminum. However, each project has a unique environment, which may either increase or decrease product service life. Significant factors include soil pH and resistivity, water pH, presence of salts or other corrosive compounds, erosion sediment, and flow velocity. The designer should investigate and document key environmental factors and use them to select an appropriate product service life.

(1) Concrete. Most studies estimated product service life for concrete pipe to be between 70 and 100 years. Of nine state highway departments, three listed the life as 100 years, five states stated between 70 and 100 years, and one state gave 50 years.

(2) Steel. Corrugated steel pipe usually fails due to corrosion of the invert or the exterior of the pipe. Properly applied coatings can extend the product life to at least 50 years for most environments.

(3) Aluminum. Aluminum pipe is usually affected more by soil-side corrosion than by corrosion of the invert. Long-term performance is difficult to predict because of a relatively short history of use, but the designer should not expect a product service life of greater than 50 years.

(4) Plastic. Many different materials fall under the general category of plastic. Each of these materials may have some unique applications where it is suitable or unsuitable. Performance history of plastic pipe is limited. A designer should not expect a product service life of greater than 50 years.

d. Future costs. The analysis should include the cost of initial construction and future costs for maintenance, repair, and replacement over the project service life. Where certain future costs are identical among all options, they will not affect the comparative results and may be excluded from the calculations. For example, costs might be identical for normal operation, inspection, and maintenance. In this case, the only future costs to consider are those for major repairs and replacement. Where replacement will be necessary during the project service life, the designer must include all costs for the replacement activities. This might include significant costs for construction of temporary levees or cofferdams, as well as significant disruptions in normal project operations.

1-5. Supportive Material

Appendix B presents design examples for conduits, culverts, and pipes. Appendixes C and D suggest outlines for evaluation of existing systems and repair of existing systems, respectively. Appendix E is a conversion factor table for metric units.

1-6. General

Reinforced concrete conduits are used for medium and large dams, and precast pipes are used for small dams, urban levees, and other levees where public safety is at risk or substantial property damage could occur. Corrugated metal pipes are acceptable through agricultural levees where the conduit diameter is 900 mm (36 in.) and when levee embankments are no higher than 4 m (12 ft) above the conduit invert. Inlet structures, intake towers, gate wells, and outlet structures should be constructed of cast-in-place reinforced concrete. However, precast concrete or corrugated metal structures may be used in agricultural and rural levees. Culverts are usually used for roadway, railway, and runway crossings.

a. Shapes. Conduits are closed shaped openings used to carry fluids through dams, levees, and other embankments. Conduit shapes are determined by hydraulic design and installation conditions. Typical shapes include circular, rectangular, oblong, horseshoe, and square sections. Circular shapes are most common. Rectangular or box-shaped conduits are generally used for large conduits through levees and for culverts carrying waterways under roads or railroads. Multiple cell configurations are commonly box shaped.

b. Loads. Conduit loadings account for earth loads, surface surcharge loads, vehicle loads, external hydrostatic pressures, and internal fluid pressures. Surface surcharge loads can be used to account for the reservoir pool water above a finished grade. Internal fluid pressure is determined by the hydraulic design of the conduit and is a concern when greater than the external pressures.

c. Materials. Construction includes cast-in-place concrete, precast concrete, steel, ductile iron, aluminum,

and plastic. In general, concrete conduits are designed as rigid conduits, and the other materials are designed as flexible conduits. In flexible conduit design, the vertical loads deflect the conduit walls into the surrounding soils, thereby developing the strength of the conduit through soil-structure interaction. Therefore, control of the backfill compaction around flexible conduits is critical to the design. Controlled backfill placement for either type of conduit minimizes pipe deflection, maintains joint integrity, and reduces water piping.

d. Joints. Joints in conduits passing through dams and levees must be watertight and flexible to accommodate longitudinal and lateral movements. Because leaking joints will lead to piping and to the premature failure of the conduit and the embankment, designers need to control conduit deflections, conduit settlements, and joint movements. Maintaining joint integrity in conduits passing through dams and levees is critical. Improperly installed pipe causes joints to leak, allows soil fines to pass through the conduit joints into the conduit, or allows internal water to pass through the conduit joints and along the outside of the conduit (piping).

e. Foundation and piping. The three common foundation problems encountered in conduit design are water piping along the outside of the conduit, the piping of soil into the conduit, the migration of soil fines into a well-washed crushed rock foundation material. Soil migration problems often lead to sink holes, which can cause embankment failure due to piping. In accordance with EM 1110-2-1913, a 450-mm (18-in.) annular thickness of drainage fill should be provided around the landside third of any conduit (Figure 1-1) regardless of type of conduit to be used, where the landside zoning of an embankment or levee does not provide for such drainage. For conduit installations with an embankment or levee foundation, the 450-mm (18-in.) annular thickness of drainage fill shall be provided and shall include provisions for a landside outlet through a blind drain to the ground surface at the levee toe, connection with pervious underseepage collection features, or an annular drainage fill outlet to the ground surface around a manhole structure.

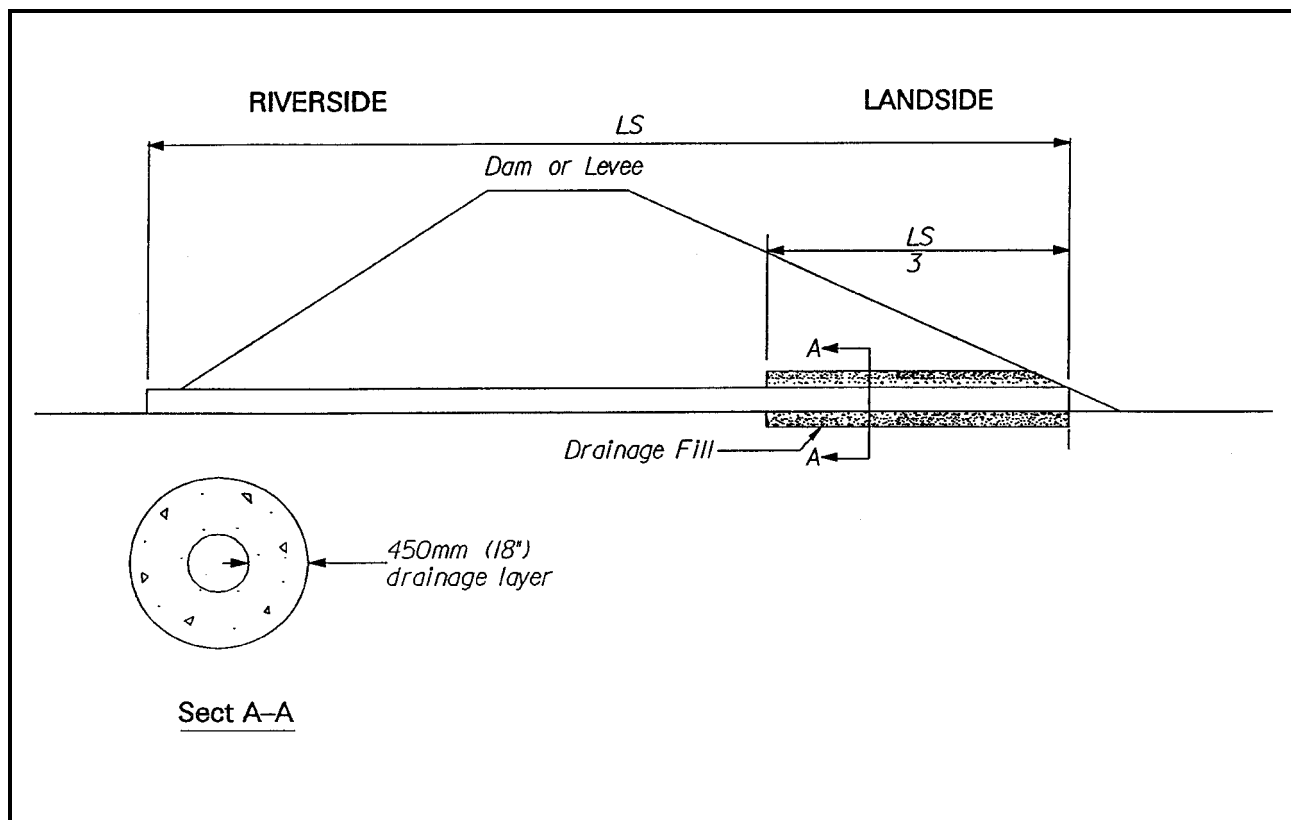


Figure 1-1. Drainage fill along conduit